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Money, Inflation and Causality in the United States, 1959-79

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After more than twenty years of work on what has been called a "monetarist counter-revolution" to Keynesian economic thought,[1] the economics profession again has come to acknowledge the importance of the money supply in determining inflation and changes in nominal GNP. Most economists would agree that, in the long run, the level of the money supply has no sustained effects on output, but solely affects prices. Furthermore, most would also agree that non-monetary (cost-push) factors can have a sustained effect on the inflation rate only if they are accommodated or "validated" by increases in the money supply.

Given the widespread agreement on these points, the debate on the causes of inflation and the proper anti-inflation policy then revolves around the following issue: what factors have typically caused movements in the rate of money-supply growth. Inflation has continued and accelerated over the last fifteen to twenty years, as has growth in the money supply. What's more, it is generally agreed—and confirmed by existing evidence—that inflation could not have continued for this long without accompanying money-supply growth. It follows, then, that the underlying causes of inflation are those which can be convincingly shown to have caused money-supply growth—either directly or indirectly—over this period.

The present paper follows this argument by conducting tests of cost-push and government-spending theories of inflation. It applies the Granger causality-test technique to determine whether various "causes" of inflation have systematically caused, or been caused by, money-supply growth. These results then provide evidence as to whether the respective variables have indeed systematically caused recent U.S. inflation. Furthermore, we argue that this technique is indeed more powerful than those commonly applied to such theories.

The arguments for the possible effects of various inflation indicators on the money supply take many forms. With respect to the cost-push theory of inflation, many analysts argue that central banks are forced to expand money and credit in response to large cost increases in various industries in order to avoid the output losses and unemployment that would normally follow such phenomena. By "accommodating" such increases through monetary expansion, a slump is avoided, but at the cost of eventually higher inflation. These cost increases thus cause sustained inflation through their effect on the money supply. In the absence of accommodation, such increases primarily would cause changes in relative prices and temporary losses in output, but at most only temporary increases in the general price level.

As for the effects of government spending (deficits) on the money supply, analysts frequently argue that central banks monetize (accommodate) large government deficits rather than financing through tax increases or through government-debt issues which would raise interest rates. Though the monetization eventually leads to inflation, those favoring such an approach argue that this is politically prefera-

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ble to the alternatives, at least in the short-run.

The next section of this paper presents a short analysis of the theory underlying our approach. It discusses the necessity of accompanying money-supply growth in order to have continuing inflation, and therefore uses the "accommodation" hypothesis to substantiate cost-push theories of inflation. Section II applies the Granger causality test technique to U.S. data for the 1959-79 period, as a means of testing these accommodation hypotheses for various measures of cost-push or government-spending-based inflationary pressure. Section III analyzes the episodic evidence on the money-inflation relationship for two particularly prominent inflation periods: the post-oil-crisis period of 1974-75, and the recent 1978-79 period. Section IV concludes with a discussion of the implications of these results.

To summarize the results, we find virtually no evidence of monetary accommodation of cost-push or "supply shock" variables, despite testing over seventeen indicators of such pressures with respect to four measures of the money supply. In the majority of cases, the result indicates "one-way causality" emanating from several or all of the money-supply measures to the respective price or cost indicator. These results are especially prevalent with respect to wage and unit-labor-cost indicators. On the other hand, the results are less conclusive for government spending and deficit measures. Some of these indicators display causal effects on the money supply, but these results are either unsatisfactory in some way or are subject to conceptual problems involving the form of the equations themselves. The general tenor of these results remains the same when the estimation form for the respective relations is altered in different ways. In addition, previous and/or concurrent money-supply growth is found to provide a reasonable explanation of most of the inflation occurring in both 1974-75 and 1978-79.

I. Conceptual Issues Behind the Money-Price Interrelationship

To reiterate, most economists would agree that inflation cannot continue without an accompanying increase in the money supply. Inflation is essentially a tendency for all prices to continue to rise, with little or no attendant movements in workers, capital, or goods among industries. And only a change in monetary conditions, viz. an increase in the money supply, can plausibly generate such an increase in all prices with little or no side-effects on the real economy. Any other disturbance would change the prices of some goods relative to others—raising some, lowering others—and would therefore induce movements of resources among industries, but not necessarily any increase in prices in general. However, because economic actors can be expected to base their decisions on real conditions and on relative prices among goods, rather than solely on money prices, an increase in the supply of money (and thence in all money prices) leaves these real conditions and relative prices unchanged, and so results in a pure inflation.[2]

Many detailed discussions of this approach can be found in early post-war inflation surveys and early discussions of various types of cost-push or supply-side inflation theories—e.g., Schlesinger (1957), Haberler (1959), and Bronfenbrenner and Holzman (1963), the last of which lists many more such examples. This literature generally recognizes that in and of themselves, supply-side shocks are sources of only temporary inflationary pressure, and become sources of ongoing inflation only when they are accommodated by the monetary system.

This being the case, it's surprising that most empirical tests of supply-side inflation theories have completely ignored what Schlesinger calls "the monetary environment," and have instead attempted to identify statistical relations between the price level and the particular "causal" factor under consideration—e.g., Means (1935, 1972) and Wachtel and Adelsheim (1976). The problem with such tests is that positive results are then equally consistent with a wide variety of conflicting inflation theories.

For example, suppose a wage-push study

finds a relation between wage increases and inflation. This might signify the existence of wage-push. However, even in a monetary theory of inflation, increasing money supplies are considered to raise demand for goods and factors, and so to raise prices and wages. In such a theory, wages might be said to respond to money before prices, or the labor market might be considered part of the transmission mechanism whereby higher money supplies lead to higher goods prices. Either development then could imply a statistical relation between wages and prices. Thus, a relationship between wages and prices could exist under a number of theories, and so in and of itself, it provides no compelling evidence of the existence of wage-push pressure. Similarly for other indicators, without evidence regarding the effect of various factors on the "monetary environment," it's impossible to tell whether the existence of a statistical relation between inflation and a given indicator represents cause or effect: whether the indicator causes inflation, or whether money-supply growth causes both the indicator and the price level to rise.

Consequently, evidence on monetary accommodation is crucially important in identifying inflation's causes. Again, an increasing money supply is the one absolutely necessary symptom, the sine qua non, of any inflation. Holding milk prices frozen, or clothing prices, or even oil or auto prices, while allowing other inflationary phenomena to continue, would not materially change the nature of the inflation process. However, holding the money supply fixed, though letting other factors continue to rise, would soon bring any inflation to a sudden halt. Therefore, identifying some factor as a systematic cause of monetary expansion is the one reliable way to mark that factor as a cause of the inflation.

Yet very few studies have taken this approach in discussing the causes of inflation. Even monetary analyses have made little attempt to document the causes of monetary expansion as rigorously as they document the effects of money on prices. There are some exceptions, such as Gordon (1977), Bazdarich (1978), and various studies of Federal Reserve reaction functions, such as Barro (1979). Of these, only Gordon and Bazdarich attempt to identify causes of inflation, and then only with a very small number of variables for a number of countries.

The present study, in contrast, considers an exhaustive list of possible indicators of U.S. inflation. We perform Granger causality tests for these indicators to determine whether they can be identified as systematic causes of monetary expansion, and thence inflation. Now one might contend that monetary accommodation is typically an episodic process— that monetary authorities react to different factors at different times—and that tests for systematic effects are therefore likely to miss important effects. Yet we argue at length that systematic effects are necessary if we are to obtain objectively meaningful results, although we also analyze two major inflation episodes to illustrate the predictive power of various inflation theories over shorter periods of time.

II. Evidence of Systematic Accommodation

The Granger causality method, which we use here to test the various inflation theories, asserts that a variable x "Granger causes" a variable y if fluctuations in x can be used to predict subsequent movements in y, that is, if fluctuations in x are systematically transmitted to y. For example, consider the equation

$$y_t = \alpha + \sum_{j=1}^{n}\beta_j y_{t-j} + \sum_{j=1}^{m}\gamma_j x_{t-j} + \epsilon_{1t}, \tag{1}$$

where x_t and y_t are values of x and y at time t, and where ϵ_{1t} is a random disturbance term. If the $(\gamma_1, \gamma_2, \ldots \gamma_m)$ vector is non-zero, then past x values can be used to predict current y values (even when the past history of y is considered as well through the $\beta_j y_{t-j}$ terms), so that x "Granger causes" y. Similarly, if, in the equation

$$x_t = \delta + \sum_{j=1}^{r}n_j x_{t-j} + \sum_{j=1}^{s}\mu_j y_{t-j} + \epsilon_{2t}, \tag{2}$$

the (μ_1, μ_2, . . ., μ_s) vector is non-zero, y is said to "Granger cause" x. When x "Granger causes" y, and y "Granger causes" x, two-way "feedback" exists between the variables. When x "Granger causes" y, but the converse doesn't hold, x is said to be econometrically exogenous to y—and similarly for the reverse.

On philosophical grounds, one would be hard pressed to assert that empirical evidence could be used to identify as metaphysical a concept as causality.[3] Thus the phrase "Granger cause" is substituted for "cause" in order to emphasize the philosophical shortcomings as well as the particular statistical phenomenon (that of predictive power) which is being identified. Still, it can be argued that the Granger-causality concept is quite relevant to our "causes of inflation" issues. In discussing the monetary accommodation issue, we cannot easily determine in what sense disturbances such as large wage settlements or oil-price increases truly cause the monetary system to expand credit. Rather, the issue is whether this process can systematically explain observed increases in the money supply, and the Granger technique would seem to be well suited for this purpose.

The existence of significant, positive causal effects from money-supply measures to inflation measures would tend to confirm the standard monetary analyses of inflation.[4] The existence of significant, positive causal effects from cost-push or government-spending indicators to money-supply indicators would indicate the existence of systematic monetary accommodation of these variables, so that they could indeed be deemed basic causes of inflation. These effects would have to be generally positive in order to show that the monetary authorities typically react to accommodate these factors, rather than perhaps countering them, which negative coefficients would suggest.

To estimate equations of the form in (1) and (2), one must choose finite values for the lag-lengths n, m, r, and s. Clearly, experimentation would allow one to find the values in each equation that best fit the data. However, such a procedure inevitably involves "peeking" at the data, and would inevitably affect the nature of the results. To avoid this problem, all tests were performed with a standard equation form using eight lags of each variable in equations (1) and (2).[5] The eight lags were considered sufficient to pick up the lagged effects of money on prices and wages, and vice versa. Following the initial tests, alternative estimation forms were also used.

Theoretical discussions of the Granger causality technique suggest the use of non-seasonally adjusted data, since seasonal-adjustment techniques can perhaps distort the statistical interrelation between two variables. We followed this approach as much as possible, adding seasonal dummies to pick up deterministic seasonality, while relying on the lagged dependent variables to prevent stochastic seasonality common to both variables from showing up as statistical causality.[6]

We performed our tests with quarterly data for the period 1957.1–1979.2, but dropped the first nine quarters from our sample period to generate lagged values and rates of change.[7] We used rates-of-change data to induce stationarity in the series, as well as for analytical reasons mentioned earlier.[8] We chose cost-push indicators which could represent specific effects, but still be general enough to be recognized—and perhaps reacted to—by the monetary authorities. We utilized four monetary aggregates—M-1 (currency plus bank demand deposits), M-2 (currency plus all bank deposits except large time certificates), the source base (sources of the monetary base as defined by the Federal Reserve Board of Governors), and the St. Louis base (the monetary base, adjusted for reserve requirement changes, as defined by the Federal Reserve Bank of St. Louis).[9] We calculated F-statistics to test the significance of each explanatory variable in "Granger causing" the respective dependent variable. A significant F-statistic indicates evidence of Granger causality for the explanatory variable in question— that is, it implies that the γ-vector in forms of equation (1), or the μ-vector in equation (2), is significantly different from a zero vector.

In testing our money-price relation, the F-statistic of 2.9 represents an effect of M-1 on the consumer-price index that is significant at the 1-percent level (Table 1, line 1). The long-run effect of 1.6 indicates that any sustained one-percentage-point change in the M-1 growth rate would generally eventually result in a 1.6-percentage-point change in the CPI inflation rate in the same direction.[10] The F-statistic of 2.6 indicates an effect of CPI inflation on M-1 growth that is significant at the 5-percent level, while the long-run effect of 0.1 indicates that a one-percentage-point change in the CPI inflation rate would eventually result in a 0.1-percentage-point change in the M-1 growth rate. The results for the other monetary indicators and the CPI can be equivalently interpreted.

All four monetary indicators have effects on the CPI with some degree of significance, as monetary theories would lead one to expect. On the other hand, the CPI has significant effects only on M-1 and M-2. This by itself need not be damaging to an accommodation hypothesis, since it could be argued that accommodation should show up in the Federal Reserve's traditional policy variables, M-1 and M-2, rather than in variables which the Fed targets only indirectly, such as the monetary-base indicators. (Even so, such accommodation, if significant, should be expected to show up to some extent in the base indicators, which are certainly affected by Fed open-market operations). Nevertheless, a more serious problem with interpreting the significant effect of the CPI on M-1 and M-2 as evidence of accommodation is that the signs of the significant coefficients for the CPI effects are negative at the shorter lags, and become positive only at the longer lags. In other words, the equations suggest that given a disturbance to CPI inflation, the Fed initially acts to counter rather than accommodate this disturbance, while its estimated reaction becomes and stays positive only after a substantial lag (twenty-five quarters!), and even then only at an insignificant level. Thus, despite the significant effects of the CPI on M-1 and M-2, the tests involving that variable do not show much sign of systematic accommodation by the Fed.

Much the same is true for other consumer-price variables. Most of the monetary indicators have significant effects on consumer food prices and the CPI excluding food. Significant reverse effects are shown only for the CPI excluding food on M-1. In this case, as seen already with the entire CPI on M-1 and M-2, the effects at the shorter lags are negative, with the estimated equation showing no real sign of accommodative tendencies by the Fed. For the GNP price deflators—for both total GNP and personal consumption—the results generally display strong one-way causality from the money-supply variables to the price indices, with no sign of systematic monetary accommodation.

The wholesale (producer) price variables similarly show no sign of accommodation. Virtually all are significantly affected by M-1 and various other monetary indicators. Yet, significant reverse effects are shown only from steel and metals prices onto M-2. Here again, the long-run effects of these variables on M-2 are small and likely insignificant. Also, these variables show no significant effects on M-1, which in the past two decades has surely been a more prominent indicator of Fed policy than M-2. In fact, the effects of steel and metals prices on M-2—in the absence of effects on M-1— may reflect business-cycle factors. Metals and steel prices are very cyclically sensitive. Similarly, because disintermediation in times of cyclically high interest rates normally affects M-2 more than M-1, it would appear that a large portion of disparate movements between M-1 and M-2 would reflect cyclical factors. Thus, the estimated relationship between M-2 and steel and metals prices (and the lack of such a relation for M-1) may reflect the existence of similar cyclical behavior in these variables.

As for labor-market indicators, we see absolutely no sign of accommodation effects on any of the monetary indicators of movements in either wages or unit labor costs (Table 1). Unit-labor-cost data are available only in seasonally adjusted form, so that those particular results should be interpreted with caution, but the results are completely consistent with those for the wage data. The general result indicates

Table 1
Causality Results Between Various Economic Indicators and the Monetary Aggregates
Eight Lags for all Variables, 1959.2–1979.2*

	M-1				M-2				St. Louis Base				Source Base			
Consumer Prices	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]
All Items	2.9***	1.6	2.6**	0.1	2.1**	1.4	2.4**	0.4	1.7*	1.1	0.9	0.1	2.2**	0.9	1.2	0.0
Food	2.6**	1.9	1.6	−0.1	2.2**	1.5	1.6	0.2	2.4**	1.2	1.0	−0.1	1.5	0.9	1.1	0.0
Excluding food	1.7	1.7	3.3***	0.3	1.2	1.7	1.5	0.4	1.8*	1.2	0.9	−0.2	2.1**	0.9	1.3	−0.2
Wholesale Prices																
All Items	2.8***	2.3	0.6	−0.3	2.2**	1.9	0.9	0.2	1.1	1.5	0.3	0.0	2.2**	1.1	0.8	−0.2
Non-Farm	1.9*	2.2	0.8	−0.1	1.6	1.9	1.5	0.2	0.9	1.4	0.4	0.0	3.0***	1.2	0.7	−0.4
Farm	2.4**	2.4	0.5	−0.4	1.5	2.0	0.7	0.1	1.4	1.5	0.3	0.0	1.8*	0.9	0.7	0.1
Metals	2.4**	2.4	0.9	−0.1	1.4	1.9	2.3**	0.1	1.9*	1.5	1.6	0.0	2.5**	1.4	0.7	−0.5
Steel	1.2	2.4	1.6	0.1	1.0	1.7	2.8**	0.1	1.5	1.6	0.9	0.0	2.0*	1.4	0.6	−0.5
Fuel	2.3**	3.8	0.7	0.0	1.6	3.1	1.0	0.1	1.9*	2.7	0.7	0.1	1.7	2.7	0.9	−0.2
Petroleum	2.1**	3.1	0.8	−0.1	1.1	2.0	1.0	0.1	1.1	1.9	0.4	0.1	1.4	1.9	0.6	−0.4
Wages for																
Nonagricultural Workers[3]	2.5**	0.5	0.7	0.4	2.4**	0.4	0.6	0.2	3.8***	0.5	1.0	0.7	3.9***	−1.4	0.7	0.5
Manufacturing	1.2	1.5	0.7	0.5	2.3**	1.5	1.1	0.5	3.9***	1.1	0.9	0.1	3.7***	1.1	1.0	0.2
Unit Labor Costs																
Private Business	2.7**	1.6	0.8	0.3	1.7	1.3	1.0	0.5	1.4	1.1	0.7	0.3	2.4**	1.0	0.2	−0.7
Manufacturing	1.7	1.6	0.4	0.1	1.4	1.1	0.8	0.2	1.3	0.8	0.9	0.1	1.8*	0.9	0.6	−0.7
Non-farm	2.7**	1.6	0.4	0.3	1.7	1.3	0.7	0.4	1.8*	1.1	0.9	0.2	2.0*	0.9	0.3	−0.7
Unemployment Rates																
All Workers[4]	3.2***	1.3	0.6	0.2	1.4	−0.3	1.2	0.2	1.5	0.6	1.9	0.3	0.8	0.4	0.4	0.1
Males 25-44[4]	3.5***	0.7	0.4	0.0	2.1**	−0.7	1.3	0.1	1.8*	−0.2	0.9	0.2	0.2	0.0	0.8	−0.1
Implicit Deflators																
GNP	3.2***	1.3	1.1	0.5	2.3**	1.1	1.1	0.6	2.7**	1.0	1.0	0.4	1.6	0.9	2.0*	−0.6
Personal Consumption Expenditures	2.4**	1.3	1.0	0.4	2.6**	1.2	1.2	0.5	1.7	1.0	0.8	0.3	2.2**	0.8	0.9	−1.0
Government Deficit[5]	1.7*	5.0	2.3**	0.1	0.5	2.2	1.8*	0.2	0.7	16.6	1.2	0.1	1.8*	15.0	2.0*	0.1
Deficit/GNP Ratio[4,6]	0.8	0.1	0.6	0.4	1.1	0.4	0.6	0.2	0.7	0.8	0.6	0.1	1.1	0.7	1.1	0.5
Government Spending[6]	0.8	0.7	1.4	0.1	0.5	0.6	2.5**	0.2	1.0	0.7	0.7	−0.2	1.0	0.7	0.9	0.4

*First column of each set shows F-statistic for effect of respective monetary aggregate on "cost" variable; second column shows long-run effect for this relation; third column shows F-statistic for effect of "cost" variable on respective monetary aggregate; fourth column shows long-run effect for this relation.

*Significant at 10 percent level.
**Significant at 5 percent level.
***Significant at 1 percent level.
[1]F-Statistic for hypothesis that explanatory variable has no effect.
[2]Long-run effect of a permanent one-percentage-point change in explanatory variable on dependent variables; see Appendix 1.
[3]Sample period: 1966.2–1979.2.
[4]"Cost" variable is in level form.
[5]Level of deficit vs. first difference of supply.
[6]Sample period: 1959:2–1978:4.

one-way causality from the monetary indicators to the labor-market indicators.

Haberler has suggested that central banks typically react more to unemployment rates than wages, and that wage increases exert sustained effects on inflation by initially raising unemployment, which the authorities then counter by monetary expansion.[11] Thus, he postulates a causal chain—from wages or labor costs to unemployment to monetary expansion to inflation. If this were in fact the case, one would still expect wages or labor costs to affect monetary expansion, although at perhaps long lags because of the two-step process. However, we have seen that this is not the case. We also tested this hypothesis directly by running causality tests between labor-cost variables and unemployment, and between unemployment rates and the money-supply indicators. Though two-way causality or feedback was found between the labor-cost variables and unemployment rates, one-way causality from money-supply growth to the unemployment rates was generally found, with no sign of "accommodation" of unemployment forthcoming. Thus, the feedback between wages (or labor costs) and unemployment is consistent with the apparent one-way causal effects of money-supply movements on all of these variables. Although wages or labor costs are usually cited prominently in cost-push analyses of inflation, our analysis found no sign of systematic effects of these variables on the "monetary environment," and so no compelling evidence for these variables as causes of sustained inflation.

Most of the tests for cost-push indicators involved price indices vis-a-vis money-stock variables, so that the *percentage rate of change* of each of the variables in a particular set could be readily related in theoretical terms as well as providing reasonably stationary time series. That is, a change in the percentage rate of growth of say, M-1 could be expected to elicit essentially the same percentage-point change in, say, the CPI inflation rate, and vice versa—no matter how high or low these rates were. Thus, equations (1) and (2) could reasonably be expected to be stable over time for these variables, and could be expected to yield statistically meaningful results.

However, we should not expect the same for various government spending or deficit variables. The government deficit, in its raw form, is measured in dollars, and so should have an increasing trend over time, both because of inflation and economic growth. Therefore it should be non-stationary. The percentage rate of change of the deficit is not a reliable indicator either, since a change from a \$1 deficit to a \$2 deficit need not elicit the same money-supply change as a shift from a \$10-billion to a \$20-billion deficit, and since any change from a balanced budget indicates an infinite percentage change.

One alternative is to run the test between the level of the deficit and the first difference in the particular money-supply variable. This equation form implies that a given dollar amount of deficit requires a given dollar amount of monetization by the Fed, and so a given dollar amount of change in the money-supply indicator. This form, although consistent with government-deficit theories of inflation, has poor statistical properties because both of the variables are non-stationary. Despite these reservations, we ran causality tests using this equation form,[12] and found significant effects of the deficit on money growth, with significant positive coefficients at the shorter but not at the longer lags.[13] But again, given the suspect nature of the variables, these results must be interpreted carefully.

Another alternative would be to induce stationarity in the deficit series by dividing it by another series with similar trend, such as nominal GNP. Such a ratio does not have dollar dimensions, and so will not be non-stationary on this count. However, the resultant equation form does not have clear theoretical validity—thus, a one-point change in the deficit as a percentage of nominal GNP need not generally elicit a fixed change in the money-supply growth rate. When we performed causality tests between the deficit/nominal GNP ratio and various money-supply growth rates, we found no significant effects in either direction.

Table 2
Causality Results Between Various Economic Indicators and the Monetary Aggregates
Four Lags for all Variables, 1959.2–1979.2

	M-1				M-2				St. Louis Base				Source Base			
Consumer Prices	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]	F[1]	LR[2]
All Items	2.5**	1.9	1.7	0.2	1.3	1.7	1.9	0.3	1.8	1.3	1.0	0.3	2.8**	1.1	1.0	0.3
Food	3.6***	1.8	1.3	0.1	1.8	1.3	1.0	0.1	2.0*	1.3	0.4	0.2	1.4	0.8	1.3	0.3
Excluding Food	1.6	1.6	1.3	0.3	1.9	1.5	1.2	0.3	3.3**	1.3	0.5	0.2	3.9***	1.3	0.3	0.0
Wholesale Prices																
All Items	2.7**	2.2	0.1	0.0	1.5	1.7	0.2	0.1	1.4	1.5	0.2	0.1	1.8	1.2	0.4	0.1
Non-farm	1.7	1.8	0.4	0.0	1.1	1.4	0.3	0.1	1.3	1.4	0.3	−0.1	1.5	1.2	0.3	−0.1
Farm	2.7**	2.2	0.2	0.0	1.2	1.4	0.5	0.0	1.5	1.5	0.2	0.0	1.2	0.9	1.0	0.2
Metals	2.0*	1.9	1.5	0.1	1.8	1.4	2.9**	0.1	3.9***	1.4	1.3	0.1	2.5**	1.3	0.8	−0.2
Steel	1.6	1.7	0.7	0.1	2.2*	1.3	1.8	0.1	2.1*	1.5	0.6	0.1	2.5**	1.5	1.0	−0.2
Fuel	1.4	1.8	0.1	0.0	0.9	1.0	0.5	0.1	1.5	2.4	0.5	0.1	1.4	2.5	0.6	−0.1
Petroleum	1.2	1.3	0.8	0.1	0.4	0.1	1.4	0.1	0.2	1.0	0.6	0.1	1.3	2.2	0.4	−0.1
Wages for																
Nonagricultural Workers[3]	4.1***	0.5	0.3	0.3	3.7**	0.2	0.3	0.0	6.2***	0.5	0.2	0.4	1.4	0.2	0.1	0.2
Manufacturing	1.6	0.9	0.9	0.5	3.6***	0.8	1.6	0.4	4.8***	0.9	1.0	0.4	3.2**	0.7	1.2	0.2
Unit Labor Costs																
Private Business	4.1***	1.5	0.4	0.2	2.0	1.0	0.8	0.3	2.2*	1.0	0.6	0.2	3.6***	0.9	0.3	−0.1
Manufacturing	2.3*	1.2	0.3	0.1	1.7	0.5	0.7	0.2	1.5	0.7	0.8	0.2	2.7**	0.9	0.7	−0.2
Non-farm	3.6***	1.5	0.3	0.2	1.8	1.0	0.9	0.3	1.9	1.0	0.8	0.3	2.9**	1.0	0.7	−0.1
Unemployment Rates																
All workers[4]	0.9	−0.9	0.5	0.1	1.4	−1.4	1.2	0.2	0.4	−0.1	1.1	0.2	0.1	0.4	0.4	0.1
Males 25–44[4]	2.8**	−0.8	0.3	−0.1	2.8**	−1.2	2.0	0.0	0.5	−0.5	0.5	0.0	0.4	0.1	1.2	−0.1
Implicit Deflators																
GNP	3.2**	1.3	1.0	0.3	1.8	1.0	1.4	0.4	3.1**	1.0	1.2	0.3	3.2**	0.9	3.3**	0.2
Personal Consumption Expenditures	2.7**	1.2	0.4	0.3	1.6	1.0	1.2	0.4	2.9**	1.0	0.5	0.3	3.6**	0.3	0.7	0.0
Government Deficit[5]	0.1	−2.7	1.9	0.1	0.2	1.5	2.3*	0.2	0.9	12.4	1.0	0.0	2.5**	11.9	2.4*	0.0
Deficit/ GNP Ratio[4,6]	1.2	−0.7	0.7	0.2	1.1	0.2	0.6	0.2	1.6	0.9	0.3	0.2	1.6	0.5	1.0	0.5
Government Spending[6]	0.2	0.0	0.6	0.2	0.2	0.3	2.7**	0.3	1.1	0.5	0.6	0.2	0.9	0.7	0.9	0.3

*First column of each set shows F-statistic for effect of respective monetary aggregate on "cost" variable; second column shows long-run effect for this relation; third column shows F-statistic for effect of "cost" variable on respective monetary aggregate; fourth column shows long-run effect for this relation.
*Significant at 10 percent level.
**Significant at 5 percent level.
***Significant at 1 percent level.
[1]F-Statistic for hypothesis that explanatory variable has no effect.
[2]Long-run effect of a permanent one-percentage-point change in explanatory variable on dependent variables; see Appendix 1.
[3]Sample period: 1966.2–1979.2.
[4]"Cost" variable is in level form.
[5]Level of deficit vs. first difference of supply.
[6]Sample period: 1959:2–1978:4.

One other alternative would be to consider the percentage rate of change in government debt, since the deficit presumably represents the first difference in the debt. But there is no reason why a stable relation should exist between the rates of change in debt and money stock. Additionally, several measures of the government debt, including on- and off-budget items and various agency-debt issues, do not provide first differences comparable to the deficit. We found no significant results when running tests using some of these variables.

Finally, we might consider government spending as a cause of inflation and money growth, since it represents the government's actual drain of goods and services from the economy—and since spending changes should correspond to deficit changes, given the largely inflexible (short-term) nature of the tax codes. Also, the percentage rate of change of government spending makes statistical sense and is likely to be stationary. However, our tests indicate that none of the money-supply variables have significant effects on government expenditures. Expenditures have a significant effect on M-2, and also have a significant effect on M-1 when data for an earlier time period are included. Even for these results, however, the coefficients of expenditures at shorter lags are negative, which would suggest that accelerations in spending are initially followed by decelerations in money growth. Obviously this finding is counter to what government spending-inflation theories normally suggest.

One might argue that our eight-quarter lag structures are not conducive to measuring accommodation effectively, that perhaps shorter lags would be better for that purpose, since if the Fed acts to accommodate inflationary disturbances, it might do so quickly in order to avoid near-term losses in output and employment. We tested this thesis by re-estimating our Table 1 equations using four-quarter lag structures (i.e., $n = m = r = s = 4$ in equations [1] and [2]), with the results shown in Table 2.

However, there is even less evidence of accommodation with these shorter lag structures. The significant effects of the CPI on M-1 and M-2 disappear, as do the effects of steel prices on M-2. The only significant "feedback" onto monetary indicators occurs for metals prices on M-2, the GNP deflator on the source base, and the deficit on M-2 and the source base. In view of the isolated nature of these results, and in view of the mitigating factors discussed for similar results in Table 1, the feedback shown in these three cases can probably be dismissed as evidence of accommodation. With our re-estimated equations, the significance of the effects of money on prices and wages also declines slightly, but the general result is still that of one-way causality from money to inflation indicators. There is certainly nothing in these results that gives any stronger signal of accommodation than the very weak evidence found with longer lag structures. We also obtained similar results with tests involving Almon polynomial-lag structures, and with tests involving smaller sample periods (see Appendix).

Conceivably we could keep dropping or adding coefficients and re-estimating equations until we found "significant" positive effects of some inflation indicator on some money-supply indicator. But after mining the data in this fashion, it would be impossible to determine whether the significance of the results actually lay in the data or in the prior beliefs of the experimenter.

For the present results, we used general-equation forms to minimize the amount of prior information that might affect the results. These tests were generally able to verify the existence of a strong effect of monetary expansion on a wide range of inflation indicators, but found no reliable accommodative effects of these indicators on the money-supply process. Thus the evidence suggests that cost-push factors do not provide a convincing explanation of continuing inflation in recent U.S. history. Much the same could be said of government-spending theories of inflation, although our equation forms were not as well suited to these types of theories as they were to cost-push theories. Also, these indicators showed more positive results, although their reliability was suspect.

III. Episodic Evidence on Inflation

Our tests found no reliable sign of systematic accommodation by the monetary authorities of cost-push or supply-side inflationary pressures. It might be argued that the tests were run over too long a time period to obtain meaningful results—that the Fed's "reaction function" for these disturbances varies or evolves over time, and/or that the Fed reacts to different factors at different times, so that a test involving one such factor over a twenty-year period is doomed to failure. However, these arguments for shifting, evanescent effects hamper the measurement of such phenomena, and also diminish the usefulness of the theory which they are intended to support.

If a theory is to be objectively testable and useful for practical purposes, it must hold over an extended period of time. To see this, recall that in our tests, we estimated a common equation form, and avoided the temptation to "doctor" the equations to improve the results. We did this not because of an unshakable belief in the equation form we used, but in order to make the data speak directly to us and thus to avoid making any subsequent changes that would inevitably bring subjective judgment into the final results.

By the same token, to argue that monetary policy reacted to, say, wages in 1957-58, and then to use 1957-58 data to "verify" this argument, inevitably involves prior knowledge of the data. This argument also effectively ignores prior historical events (perhaps inflationary money growth in 1955-56) that might better explain 1957-58 developments. We would be dealing with a sample of one period, i.e. the 1957-58 period, which was drawn from the whole set of historical data in a non-random way. It is difficult to determine the reliability of any such demonstration unless the evidence holds over an extended period of time. Also, tests over such a narrowly specified period could provide evidence of an effect only for that period. Knowing that money growth and inflation, say, in 1957-58 were caused by wage increases would not necessarily tell us anything about the causes of inflation in other periods.

A verifiable, useful hypothesis about monetary accommodation and inflation therefore should be supported by evidence of a systematic link between the particular variable and the money supply over a period of time long enough to allow statistical identification. Although we were unable to find that type of evidence in our earlier analysis, it is nevertheless interesting to examine the explanatory power of the competing theories in certain specific periods.

Consider first the 1973-75 inflation. This burst of inflation followed three possible causative factors: the removal of mandatory wage and price controls, largely completed by late 1973; the oil crisis in late 1973, which resulted in a quadrupling of crude oil prices; and a worldwide acceleration in money-supply growth starting in late 1970.[14] The removal of wage and price controls could be expected to precipitate a temporary acceleration in inflation in 1973-74 to make up for the 1971-73 suppression of inflation, therefore transfering it to the period immediately following the removal of controls. The oil-price shock, on the other hand, could have caused a temporary acceleration in inflation for reasons discussed earlier.

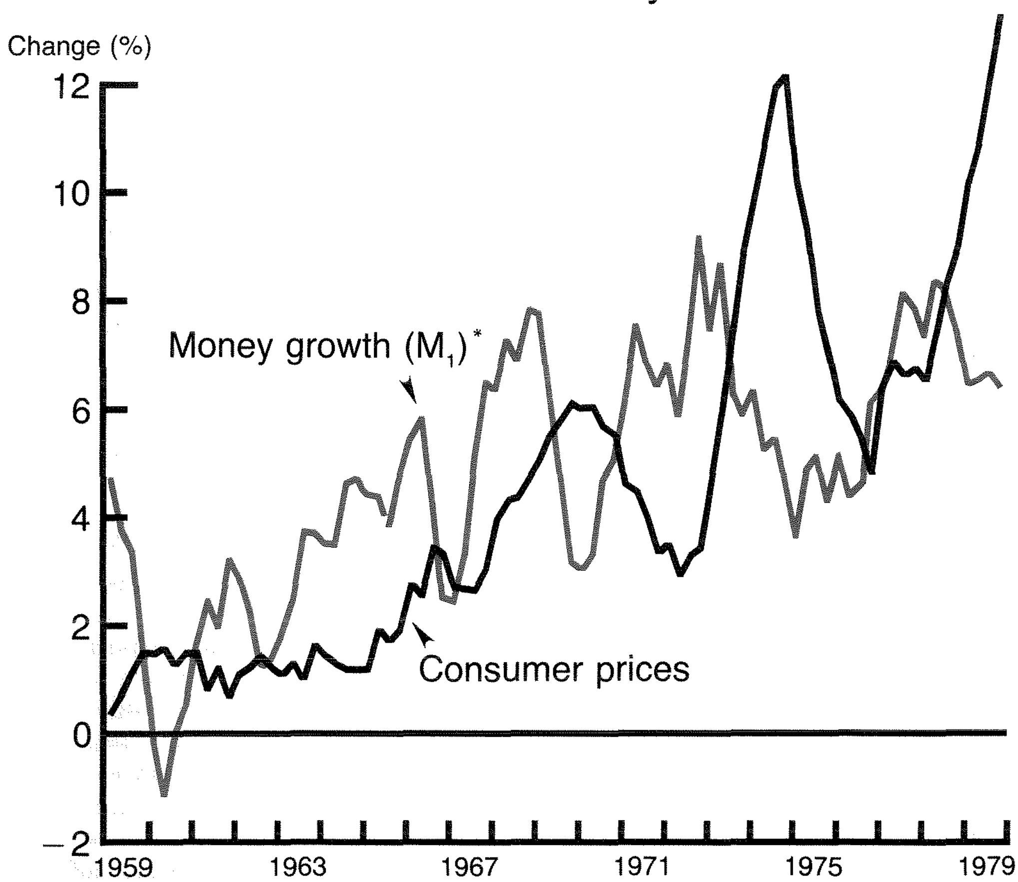
In any event, monetary accommodation was not evident in 1973-74, because money-supply growth was decelerated sharply both before and after these several developments (Figure 1).[15] The Federal Reserve apparently moved to counter—rather than accommodate—inflationary forces following the removal of controls and the oil-price shock. Therefore, on the basis of our earlier analysis, none of these factors could be regarded as sources of continuing inflation even in this subperiod.

This leaves the question: how important are these factors as causes of transitory inflation over the period at hand? We can address this question by determining how much inflation can be explained by monetary forces alone, attributing any remaining inflation to the non-monetary factors mentioned. Because the existence of controls probably shifted monetary inflation to the post-controls period, the simulations were performed starting in third-quarter 1971, the date of imposition of the controls. Because the suppressed inflation presumably took two years to work through the economy, the simulation period was terminated in fourth-quarter 1975, two years after the end of the controls period.[16]

Thus, the inflation-money version of equation (1) was simulated over 1971.3-1975.4 for four general measures of inflation (CPI, WPI, GNP deflator, and GNP deflator for personal consumption goods) and for the four basic money-supply measures.[17] Because the results could be biased by using an equation form estimated from a sample period including 1971.3-1975.4, we performed simulations for equations estimated from two other sample periods: 1959.2-1971.2, designated the "short" sample period, and 1959.2-1971.2 /1976.1-1979.2, designated the "bracketed" sample.

As would be expected, the simulations yielded generally positive "forecast" errors over the early part of the period, when controls should have suppressed inflation below the level implied by previous money-supply growth, and generally negative "forecast" errors over the latter period, when the removal of controls should have pushed inflation above levels predicted by previous money-supply growth. Yet the monetary aggregates do a

Chart 1
Inflation and Money Growth



*Adjusted for automatic transfer accounts (ATS) fairly good job of explaining cumulative inflation over the entire period (Table 3). M-1 growth can explain all but 6 percentage points of the 37.9-percent cumulative increase in the CPI in the short-sample simulation, and actually overpredicts inflation in the other simulations. Similar results hold for the deflator simulations. In contrast, simulation errors are larger by as much as 31 percentage points for the 56.2-percent cumulative increase in the WPI. The disparity can be explained in part by the fact that the WPI involves goods at all stages of the production process, and so probably over-counts the effects of an increase in the price of a factor (like oil) which is prominently used in a number of products. Also, as our earlier analysis suggests, a supply shock should primarily affect relative prices. In the case of the oil shock, one would expect the relative returns to other productive factors, such as labor and capital, to fall relative to that for energy. This would then increase the level of wholesale prices relative to consumer (retail) prices, since the latter has a higher service and labor content, while the former is more sensitive to fuels and primary products.

In any case, previous movements in money-supply growth (along with the transferring effects of controls) are able to explain most of the 1973-75 inflation, with the divergent movements between the WPI and the other measures apparently due to higher relative prices for oil and energy inputs. These results, and the apparent lack of monetary accommodation of various price shocks, suggest that this period was not demonstrably different from other periods in terms of the interrelation between monetary policy and inflation.

In similar fashion to the earlier debate, some analysts today describe the 1978-80 inflation as being a new strain of the inflationary "virus," contracted from different "germs," and so somehow immune to traditional anti-inflation policy prescriptions. They tend to blame the current inflation on large food-price increases in early 1978, and oil-price increases in 1979, spread through the economy by workers seeking to index their wages to the cost of living. Some argue that this widespread trend to indexing makes inflation more immune to restrictive monetary policy. Still, the arguments propounded today resemble those made in 1973-75, although perhaps on a smaller scale.

We can gain some insight into the nature of

Table 3
Simulation of Money-Inflation Effect, 1971.3–1975.4

Inflation Indicator	Actual Inflation Over Period	Inflation Forecasted (and Forecast Error) By: M-1	M-2	St. Louis Base	Source Base
Short Sample					
Consumer Price Index	36.9	29.2 (5.9)	33.8 (2.3)	26.1 (8.5)	21.0 (13.1)
Wholesale Price Index	56.2	19.3 (31.0)	24.4 (25.5)	23.4 (26.6)	17.3 (33.2)
GNP Deflator	35.9	38.2 (−1.6)	56.1 (−14.8)	40.6 (−3.4)	35.9 (0.0)
Personal Consumption Deflator	34.3	26.6 (6.1)	34.3 (0.1)	25.5 (7.0)	23.4 (8.9)
Bracketed Sample					
Consumer Price Index	36.9	38.8 (−1.4)	41.8 (−3.6)	36.6 (0.2)	33.6 (2.5)
Wholesale Price Index	56.2	34.5 (16.1)	37.4 (13.7)	35.6 (15.2)	31.0 (19.3)
GNP Deflator	35.9	33.8 (1.6)	39.6 (−2.7)	35.3 (0.5)	31.2 (3.6)
Personal Consumption Deflator	34.3	32.4 (1.5)	40.8 (−4.8)	33.2 (0.8)	28.5 (4.5)
Long Sample					
Consumer Price Index	36.9	38.5 (−1.2)	37.4 (−0.4)	34.8 (1.6)	31.0 (4.4)
Wholesale Price Index	56.2	44.8 (7.9)	43.6 (8.8)	41.1 (10.7)	32.8 (17.6)
GNP Deflator	35.9	35.6 (0.3)	34.8 (0.8)	33.1 (2.2)	32.0 (3.0)
Personal Consumption Deflator	34.3	33.2 (0.9)	32.0 (1.7)	31.2 (2.4)	27.7 (5.2)

this inflation by analyzing it in terms of the money-price relations developed earlier. Money-supply growth started to accelerate in late 1975 or early 1976, following two years of declining growth rates. (Figure 1). This development would suggest an acceleration in inflation starting in late 1976 or early 1977, and becoming very strong by about early 1978, as actually occurred. However, there were no signs of an acceleration in labor costs, nor any identifiable supply shocks, at the time of the monetary acceleration. It seems unlikely, then, that the monetary acceleration of 1976-77 was generated by accommodative Federal Reserve behavior, at least attributable to cost-push pressures.

To measure these factors more precisely, we again simulated the inflation-money supply equations for various indicators. To avoid biasing the results, we again re-estimated the equations over sample periods not including the respective simulation period. Thus, the equations were estimated over the 1959.2-1977.4 period, and simulated over 1978.1-1981.4 (first simulation), then estimated over 1959.2-1978.4 and simulated over 1979.1-1981.4 (second simulation), and finally estimated over 1959.2-1979.4 and simulated over 1980.1-1981.4.[18]

Despite the correct "phasing" evidenced in recent years between money growth and inflation, significant amounts of inflation clearly appeared to be outside the explanation of previous money-supply growth (Table 4). For example, CPI inflation was two percentage points higher in 1978 and four percentage points higher in 1979 than would be suggested by conditional forecasts based on M-1 growth.[19] These results would seem to reflect the impact of the 1978 food-price shock and the 1979 oil-price shock. Even so, the first simulation results are still able to explain a large part of the recent inflation acceleration.

To the extent that large, recognizable shocks to food and oil prices explain the rest, this argument is consistent with the previous analysis, where such shocks were said to have possibly permanent effects on the price level (independently of the money supply) and so temporary effects on the inflation rate. However, this can be true only to the extent that the simulation errors evidenced in Table 4 represent the effects of unforseeable shocks. If these errors could be attributed instead to the systematic effects of factors predictable on non-monetary grounds, the power of the money-price relation might be diminished. To analyze such questions, we should consider what forecasters were predicting about 1978-79 inflation in 1977-78. These analysts, especially those employing large econometric

Table 4
Simulations of M-1 Inflation Equation (1978–81)
Compared to Forecasts By Major Analysts

Consumer Price Index		Simulation Results Over Sample Period			Forecasts By: Wharton Econometrics			Data Resources Inc.			Time Magazine Board of Economists
	Actual	59.2–77.4	59.2–78.4	59.2–79.4	12/31/77	12/1/78	12/3/79	12/21/77	12/27/78	12/20/79	
1978	9.0	7.0	—	—	5.5	—	—	5.8	—	—	6.2[1]
1979	13.3	8.0	9.0	—	6.3	7.1	—	5.3	7.8	—	7.5[1]
1980	—	7.9	8.1	11.8	—	6.3	11.3	5.7	6.9	10.4	9.1[1]
1981	—	6.4	6.1	7.9	—	—	8.7	—	6.8	9.1	
GNP Deflator											
1978	8.2	6.5	—	—	5.6	—	—	6.0	—	—	—
1979	8.9	7.7	8.8	—	5.7	6.6	—	5.4	7.4	—	—
1980	—	7.8	8.3	8.8	—	6.1	9.4	6.1	7.1	9.4	—
1981	—	6.8	7.1	7.2	—	—	7.8	—	6.9	9.2	—

[1]This rate is the December over previous December increase.

models, presumably utilized a wide range of available information in their forecasts. If our simulations compare favorably to their forecasts, it would suggest that recent "nonmonetary" inflation was in fact due to large unforseeable shocks to oil and food prices rather than to systematic defects in the money-price relation.[20]

As it turns out, most analysts experienced forecast errors larger—and in some cases much larger— than the errors for the money-price simulations shown in Table 4. Most late-1978 forecasts showed inflation slowing to below 8 percent in 1979. The simulations—using money-supply information through 1979 but price information through only 1977 or 1978—showed inflation remaining steady or even accelerating in 1979. Despite underpredicting 1979 CPI inflation by four percentage points, the simulation predictions were certainly more accurate than those of the major forecasters.

This does not necessarily mean that the money-price equation is a superior forecasting tool, because the simulations utilized information not available to the forecasters: actual-money-supply growth over the respective simulation periods.[21] However, it does suggest three important points: a) actual money-supply growth is indeed helpful for predicting inflation in the present period; b) the large errors, apparent in both the simulations and outside forecasts, represent the effects of random, unpredictable shocks, rather than systematic defects in the money-price relation; and c) M-1 does a creditable job of explaining inflation in 1978-79, accounting for an acceleration in the underlying rate of inflation to the 8-to-10 percent range.

The remaining CPI inflation in 1979 is clearly due to the short-term effects of large oil-price increases, given the larger errors experienced by forecasters using more structural information—and given the lack of large simulation errors for the GNP deflator, which does not directly include import prices, and thus fails to reflect the full impact of OPEC price actions. Such a random shock to prices can temporarily pull measured inflation rates away from rates predicted by the money supply. However, the expansion in money-supply growth and the acceleration in inflation clearly occurred well before oil prices surged, so that the recent inflation could not be attributed to monetary accommodation of oil-price increases.

In summary, the 1973-75 and 1978-79 episodes of inflation did not show any greater sign of accommodation than did the 1959-79 period as a whole. In each case, the acceleration in inflation was preceded by an acceleration in money-supply growth. The money-supply behavior then was able to explain a predominant portion of actual measured inflation, with the remaining part clearly attributable to the temporary effects of oil- and food-price shocks. As for 1980, the money-price relation suggests that inflation, though declining, will remain quite high through the year, even if M-1 grows no faster than the 5-percent rate assumed in the simulations.

IV. Summary and Conclusions

In this article, we have examined the direction of Granger (econometric) causality between the U.S. money supply—as measured by four prominent monetary aggregates—and a number of variables considered representative of cost-push and government-deficit inflationary pressures. We found widespread and significant "causal" effects from the money-supply measures to the price or cost variables, but found no reverse effects, at least not of a nature that would suggest monetary-accommodation. Thus, we found little if any evidence of the systematic existence of cost-push inflation in the last twenty years. Furthermore, even in two recent episodes of inflation acceleration, the behavior of the money-supply measures alone was capable of explaining these experiences reasonably well, with little evidence of accommodation. Though some signs of systematic effects of government-spending variables on the money supply existed, these effects were not particularly convincing.

These results therefore fail to support the commonly-held theory of a wage-price spiral: the idea that increasing labor costs cause increasing prices, which cause workers to seek still higher wages, with the process continuing indefinitely on its own momentum. Such a "perpetual motion inflation machine" could not not continue on its own without continuous "refueling" in the form of an accommodative monetary policy. Yet, there is no convincing evidence that the Federal Reserve has conducted monetary policy in such an accommodative manner. Rather, the increases in the money supply have more typically acted as an underlying cause of the increases in wages and prices. More than providing the fuel to keep the engine running, an increasing money supply has apparently provided the initial spark igniting the engine.

Some might contend that at root the various theories of inflation all say much the same thing. Cost-push theorists might see income-share struggles as first affecting wages and prices, and thence forcing accommodation by monetary authorities who seek to avoid disruptions to output and employment. At the same time, monetary theorists might emphasize government efforts to achieve unattainable economic goals (or to avoid painful explicit tax increases) in order to appease impatient electorates, thereby leading to autonomous monetary expansion and thence inflation. At this level, both sides ultimately seem to blame inflation on socio-political pressures, and disagree mainly about the mechanisms which transmit these pressures.

Yet, it can be argued that the two approaches actually give rise to quite different insights and policy implications. If nothing else, the monetary approach emphasizes the importance of the money supply in continuing the inflation process, whereas this role is often left implicit in the cost-push formulation. More importantly, identifying the actual channels through which inflationary forces operate suggests different policy strategies for slowing inflation. It is true that if socio-political struggles underlie any inflation, then any effective anti-inflation policy must educate the public about the futility of attempting to resolve struggles in this way, and must devise political reforms to keep these struggles from being translated into inflation. But it is also true that if cost-push channels cannot be identified as crucial in the transmission of these struggles to inflation, as we suggest, then policy reforms should start with channels that can be identified. Thus, reform should possibly begin with the operations of monetary policy and related policy influences from the executive and legislative branches—rather than with income policies designed to control industrial sectors which have typically reacted to rather than instigated inflationary pressures. Of course alternative channels of inflationary pressures operating on the money supply (such as government spending or "finetuning" tendencies) may be just as hard to identify as cost-push pressures are.

Indeed, our study suggests that while we can easily identify money-supply expansion as a cause of inflation, we cannot easily explain why the money supply grows. Neither major set of theories—cost-push or government-spending—provides convincing evidence on this point. Fluctuations in interest rates (actually, credit market conditions) may be able to explain money-supply growth in relation to former (pre-October 1979) Federal Reserve operating procedures, but a definitive answer to this issue awaits further research.

In closing, we may note a few other implications of our results. First, the two monetary base measures exerted significant effects on many of the cost variables, and in some cases actually outperformed the broader money-stock measures. This suggests that monetary-base information can be useful in judging the inflationary impact of monetary factors when financial innovations (e.g., automatic transfers) blur the meaningfulness of the money-stock data. Thus, monetary policymaking need not be totally at a loss in times of financial innovation. Also, M-1 generally outperformed the broader M-2 measure, both in terms of the statistical reliability of its effect on various cost variables and in terms of its independence of such variables. This observation will not resolve the long-standing M-1 vs. M-2 controversy, but it should provide a useful piece of evidence on that subject.

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APPENDIX
Alternative Estimation Forms

This Appendix discusses the results of estimations of alternative equation forms for equations (1) and (2), for the variables listed in Table 2. Once again, Table 2 showed the results of estimating the equations:

$$y_t = \alpha + \sum_{1}^{8} \beta_j y_{t-j} + \sum_{1}^{8} \gamma_j x_{t-j} + \epsilon_{1t}, \tag{1}$$

$$x_t = \delta + \sum_{1}^{8} n_j x_{t-j} + \sum_{1}^{8} \mu_j y_{t-j} + \epsilon_{2t}. \tag{2}$$

The estimations of the equations (1) and (2), as documented so far, were done through ordinary least-squares estimation (OLS), with no constraints imposed on the structure of the lag coefficients, other than the lag-length assumption.

While this technique is common in time-series analyses and causality studies, the reader may object to the existence of multicollinearity among the regressor variables, because of the number of lagged regressors involved. A technique designed to minimize this multicollinearity and preserve degrees of freedom in estimation is that of polynomial distributed lags (PDL). This technique assumes that the coefficients of a given distributed lag are related to each other through a polynomial function. For example, in equation (1), for the lag set $\gamma_1, \ldots, \gamma_8$, a second-degree PDL specification would assert that

$$\gamma_j = aj^2 + bj + c, \qquad j = 1, \ldots, 8$$

where a, b, and c are the coefficients of the polynomial. This specification would necessitate estimation of only three parameters, a, b, and c, rather than eight, $\gamma_1, \ldots, \gamma_8$. Also, the technique for estimating this equation would use three variables, S_{1t}, S_{2t}, and S_{3t} which are linear combinations of $x_{t-1}, \ldots, x_{t-8}$, and allegedly the multicollinearity among these three variables would be less of a problem than that among the eight lagged values of X_t.

Without speculating on the validity of this technique, the equations summarized in Table 2 were re-estimated, first under a specification of second-degree PDL for all lag sets, and then under a specification of third-degree PDL for all sets. No further constraints were imposed on the lag structure. The results of these estimations are shown in Tables A-1 and A-2 respectively. Also, by comparing the results of the PDL with that of the OLS estimation of the same equation, the suitability of the PDL specification can be tested. An F-test can be derived, a significant value of which would indicate that the data are inconsistent with the PDL specification. These F-statistics are shown in Tables A.1 and A.2, along with the F-statistics for the hypothesis that the explanatory variable does not "cause" the dependent variable.

For example, consider the first set of results in Table A.1. The first F-statistic of 6.2 indicates that the effect of M-1 on the CPI is significant at the 1-percent level. The 0.8 "PDL" F-statistic (not significant) indicates that the second degree PDL assumptions for this regression are not inconsistent with the data. The 0.3 F-statistic shows that the effect of the CPI on M-1 is statistically insignificant. The 3.9 "PDL" F-statistic indicates that the PDL assumption for this regression is inconsistent with the data, i.e. that the equation regressing M-1 growth on lagged M-1 growth and CPI inflation has coefficients which do not obey a second-degree polynominal specification.

The results of Tables A.1 and A.2 are clearly similar to those of Tables 1 and 2. While the F-statistics suggest that PDL assumptions are generally inappropriate for regressions using money-supply growth—especially M-1 growth—as the dependent variable, this generally mirrors the inappropriateness of the PDL for the time-series behavior of the money supply itself. Generally, the feedback effects on inflation indicators themselves on the money supply are too weak or non-existent to be materially distorted by PDL assumptions.

Finally, Niskanen (1978) has referred to an obvious change in the conduct of monetary policy starting in the late 1960's. If policy re-

Table A.1.
Causality Tests Using an Unconstrained Second Degree Polynomial Lag Structure (Eight Quarters Long) for All Variables*

	M-1				M-2				St. Louis Base				Source Base			
Consumer Prices	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL
All Items	6.2***	0.8	0.3	3.9***	4.2***	0.7	0.9	3.0**	3.1**	0.7	0.2	1.2	2.8**	1.1	0.3	1.6
Food	5.9***	0.7	0.4	2.9***	4.1***	0.8	0.3	2.6**	2.9**	1.3	1.2	1.0	1.3	1.0	1.4	1.2
Excluding Food	4.6***	0.7	1.0	4.2***	2.3*	0.9	1.4	2.1**	1.9	1.5	0.3	0.7	5.5***	0.8	0.6	1.2
Wholesale Prices																
All Items	5.8***	0.8	0.2	1.9*	4.5***	0.7	0.7	1.7	3.0**	0.3	0.1	0.7	1.3	1.6	0.5	1.2
Non-Farm	6.2***	1.2	0.1	2.2**	5.4***	1.2	0.7	2.2**	2.6*	1.4	0.3	0.8	2.5*	3.3***	0.5	1.1
Farm	4.1***	1.2	0.4	1.8*	3.1**	0.8	0.8	1.7*	1.7	1.1	0.5	0.7	1.4	1.5	1.1	0.9
Metals	4.7***	2.0**	0.3	2.3**	4.1***	1.4	0.9	3.0***	2.8**	2.1**	0.5	1.8*	2.8*	2.6***	0.9	1.0
Steel	3.6**	1.5	0.1	3.0***	2.3*	1.7	0.7	3.5***	2.5*	2.1**	0.2	1.2	2.7**	2.5**	1.1	0.8
Fuel	5.0***	1.4	0.2	2.1**	3.0**	1.4	0.9	1.7	2.7**	1.8*	0.2	1.0	2.9**	1.5	0.3	1.3
Petroleum	4.9***	2.7***	0.5	2.0**	1.3	3.0***	1.3	1.6	1.1	3.0***	0.2	0.8	1.5	3.2***	0.3	1.1
Wages For																
Nonagricultural Workers[3]	2.4*	2.0*	0.7	0.9	1.3	2.2**	0.1	0.8	1.9	3.2***	0.5	0.9	6.0***	1.9*	0.9	1.2
Manufacturing	3.1**	0.8	0.6	2.0*	3.7**	1.4	0.6	1.9*	4.3***	2.4**	0.4	1.2	5.7***	1.9*	0.2	1.4
Unit Labor Costs																
Private Business	6.6***	0.6	0.7	0.6	3.2**	0.7	1.1	1.4	3.5**	0.5	0.8	1.6	4.4***	0.9	0.3	0.6
Manufacturing	4.5***	1.4	0.3	0.4	3.5**	1.5	0.4	1.5	2.2*	1.7*	0.6	1.8*	2.6*	2.1**	0.3	0.9
Non-Farm	6.6***	0.7	0.5	0.4	3.3**	0.7	1.0	1.3	3.8**	0.7	0.8	1.7*	3.9**	0.8	0.3	0.6
Unemployment Rates																
All Workers[4]	6.4***	9.2***	1.2	0.3	3.7**	7.8***	1.8	1.4	2.1	8.9***	1.6	2.3**	1.5	8.1***	0.1	0.8
Males 25–44[4]	4.4***	6.0***	0.7	0.3	3.4**	4.9***	1.6	1.6	1.6	5.3***	1.0	1.6*	1.0	3.6***	0.4	1.1
Implicit Deflators																
GNP	4.5***	1.3	1.6	0.6	2.7*	1.1	1.7	1.4	4.7***	0.9	0.8	1.8*	2.9**	0.5	0.8	1.9*
Personal Consumption Expenditures	5.6***	0.6	0.5	0.8	4.3***	1.2	1.1	1.7*	3.8**	0.7	0.2	1.8*	3.9**	1.0	1.1	0.9
Government Deficit[5]	1.2	2.9***	3.5**	1.3	0.9	1.9*	3.1**	1.8*	1.6	1.8*	1.6	1.4	4.0**	2.0**	2.1*	1.8*
Deficit/GNP Ratio[4]	1.4	1.8*	0.9	1.3	0.1	2.6**	0.5	1.4	0.9	1.8*	0.5	0.8	1.3	2.1**	0.3	1.5*
Government Spending	1.0	2.6***	0.1	2.2**	0.4	2.5**	0.3	3.2***	0.7	2.9***	0.1	1.0	1.2	2.8***	0.7	1.3

*The first column in each set shows the F-statistic for the effect of the respective monetary aggregate on the "cost" variable; second column shows the F-statistic for the hypothesis that a second degree PDL fits this relation; third column shows the F-statistic for the effect of the "cost" variable on the monetary aggregate; fourth column shows the F-statistic for the PDL for this relation.

*Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

[1]F-statistic tests the hypothesis that the explanatory variable has no effect on the dependent variables. [2]F-statistic tests the hypothesis that the PDL constraint is consistent with the data. [3]Sample period: 1966.2–1979.2. [4]"Cost" variables are in level form. [5]This result is between the deficit and first difference in the respective monetary aggregate.

action did indeed shift starting in the late 1960's, one might expect the causality results between the money supply and various cost indicators to be different in the last ten years than in the previous ten. As a first attempt to allow for such changes, some of the results in Table 2 were re-run with a sample period consisting of 1969.2-1979.2, and a third degree PDL specification imposed to preserve degrees of freedom. Also, some of the results were re-run over the 1959.2-1979.2 period in OLS form with a dummy variable for the last ten years, in an attempt to pick up obvious shifts in the money-supply accommodation equations. These estimations did not show any substantive changes in the causality results, nor were any signs of a shift in policy behavior apparent.

Table A.2
Causality Tests Using an Unconstrained Third Degree Polynomial Lag Structure (Eight Quarters Long) for all Variables*

	M-1				M-2				St. Louis Base				Source Base			
Consumer Prices	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL[2]	F[1]	F-PDL
All Items	5.0***	0.8	0.2	4.5***	3.3**	0.8	0.7	3.7***	2.6**	0.8	0.4	1.2	2.2*	1.4	0.7	1.3
Food	4.9***	0.6	1.1	2.8**	3.8***	0.6	0.3	3.1***	3.1**	0.7	1.2	0.9	0.9	1.3	1.1	1.1
Excluding Food	3.3**	0.8	2.0*	4.1***	1.8	1.0	2.8**	1.7	1.6	1.6	0.3	0.7	4.0***	0.9	1.1	0.8
Wholesale Prices																
All Items	5.0***	0.7	0.2	2.1*	3.8***	0.7	1.3	1.7	2.1*	0.3	0.2	0.7	1.6	1.6	0.5	1.0
Non-Farm	3.8***	1.0	0.4	2.3**	3.3**	1.0	1.8	2.1*	2.2*	0.8	0.2	0.8	4.1***	1.9*	0.6	0.9
Farm	3.9***	1.0	0.3	2.0*	2.6**	0.8	0.2	2.1*	1.6	1.1	0.6	0.5	1.1	1.7	1.0	0.7
Metals	3.8***	1.6	0.5	2.3**	2.5**	1.2	2.2*	2.8**	3.1**	1.4	0.5	2.1**	4.0***	1.5	0.9	0.8
Steel	3.0**	0.6	0.5	3.1***	1.7	1.0	1.2	3.8***	2.8**	0.9	0.7	1.3	3.9***	0.9	0.8	0.7
Fuel	3.8***	1.1	0.2	2.3**	2.0	1.2	1.0	1.9*	2.0	1.6	0.7	0.8	3.0**	0.9	0.3	1.3
Petroleum	4.0***	2.8**	1.7	1.5	1.0	3.3***	1.9	1.5	1.4	3.0***	0.2	0.8	1.1	3.6***	0.4	0.9
Wages For																
Nonagricultural Workers[3]	1.8	2.3**	0.5	1.0	1.1	2.7**	0.2	0.8	1.9	3.6***	1.0	0.9	5.0***	2.1*	1.0	0.9
Manufacturing	2.2*	1.0	0.7	2.0*	2.6**	1.8	0.5	2.3**	3.5**	2.8***	0.3	1.3	4.1***	2.4**	0.8	1.1
Unit Labor Costs																
Private Business	5.6***	0.2	0.6	0.6	3.3**	0.3	1.1	1.0	2.7**	0.3	0.6	1.8	3.4**	0.8	0.2	0.5
Manufacturing	3.5**	1.6	0.4	0.3	2.8**	1.7	0.5	1.1	2.0	1.9	0.4	2.1**	2.0	2.5**	0.9	0.6
Non-farm	5.3***	0.4	0.5	0.2	3.2**	0.4	1.0	0.7	3.5**	0.4	0.7	1.6	3.5**	0.5	0.2	0.5
Unemployment Rates																
All Workers[4]	4.9***	3.6***	1.1	0.2	2.2*	3.1***	1.7	0.9	1.4	3.7***	1.3	2.7**	0.2	3.6***	0.3	0.7
Males 25–44[4]	3.7***	3.1***	0.7	0.1	2.4*	2.4**	1.6	1.1	1.8	2.3**	0.9	1.8	0.5	1.2	0.4	1.0
Implicit Deflators																
GNP	3.8***	1.4	1.3	0.5	2.5**	1.1	1.5	1.0	3.6***	1.0	0.5	2.2**	2.7*	0.5	0.5	2.2**
Personal Consumption Expenditures	4.2***	0.6	0.4	0.9	3.0**	1.4	0.8	1.4	2.8**	0.7	0.3	2.1**	3.4**	0.9	0.7	1.0
Government Deficit[5]	0.7	2.6**	2.7**	1.5	0.7	1.4	2.4*	2.0*	1.4	1.2	1.8	1.4	2.8**	1.6	2.9**	1.2
Deficit/GNP Ratio[4]	0.9	2.3**	0.7	1.3	0.1	3.2***	0.8	1.5	0.7	2.2**	0.9	0.6	1.3	2.4**	1.5	0.9
Government Spending	0.8	2.1**	0.3	2.3**	0.3	2.1**	1.2	3.3***	0.6	2.4**	0.7	0.8	1.0	2.3**	0.4	1.2

*First column in each set shows the F-statistic for the effect of the respective monetary aggregate on the "cost" variable; second column shows the F-statistic for the hypothesis that a third degree PDL fits this relation; third column shows the F-statistic for the effect of the "cost" variable on the monetary aggregate; fourth column shows the F-statistic for the PDL for this relation.
*Significant at 10 percent level.
**Significant at 5 percent level.
***Significant at 1 percent level.
[1]F-statistic tests the hypothesis that the explanatory variable has no effect on the dependent variables.
[2]F-statistic tests the hypothesis that the PDL constraint is consistent with the data.
[3]Sample period: 1966.2–1979.2.
[4]"Cost" variables are in level form.
[5]This result is between the deficit and first difference in the respective monetary aggregate.

1. Johnson's (1971) is the best known use of this phrase. Earlier users are cited by him as well.

2. This is obviously a very capsule treatment of the neutrality-of-money hypothesis. Among other things, it implicitly assumes 1) that economic actors do not have "money illusion," and so will not feel better (worse) off if nominal wealth and all money prices increase (decrease) by an equal proportion; 2) that government bonds do not represent net wealth to the private sector (that is, the interest payments forthcoming from them are offset by future tax revenues needed to service the debt—see Barro (1974) for a discussion of this, and Metzler (1951) for a model where the net wealth status of bonds prevents neutrality); and 3) that the distribution of wealth in an economy is not irretrievably altered by the process of convergence to equilibrium following an increase in the money supply. See Patinkin (1963), Friedman (1956), or Barro and Grossman (1976) for extended treatments of these issues.

The neutrality hypothesis does not rule out growth in output or employment over time, but only specifies that these will eventually be unaffected by the level of the money supply. Nor does neutrality imply that real variables are independent of the **rate of change** of the money supply, this latter concept being commonly known as "super neutrality."

The reader should note that these neutrality concepts, while convenient for showing the effects of money on prices, are not necessary conditions for the inflationary effects of an increase in the money supply.

3. This point is discussed in Jacobs et al. (1978).

4. Monetary discussions of inflation state that sustained changes in the rate of money-supply growth, relative to previous trends, will lead to changes in the trend rates of change in prices and wages. This description allows for the possibility that a positive rate of money-supply growth (usually estimated at about 1% per year for M-1 in the U.S.) will allow a zero inflation rate. Even in this case, it is still true that sustained changes in money growth above this rate will lead to sustained inflation.

5. Because lagged dependent variables are included in equations (1) and (2), the eight-quarter lag structure does not constrain the total lag from the explanatory to independent variables to be eight quarters or less. That is, in (1), y_t depends on $y_{t-1}, \ldots, y_{t-8}$, but since y_{t-8} depends on x_{t-16}, y_t will then indirectly depend on x_{t-16}, and a very long lag can be estimated by the equation form described in the text.

6. Deterministic seasonality refers to the perfectly predictable seasonal variation in a variable, while stochastic seasonality refers to seasonal fluctuation that varies randomly, perhaps in correlation with other seasonal variables. For example, suppose M-1's growth rate was on average 6 percentage points higher in the fourth quarter, due to Christmas financing needs, than in the first quarter. Then M-1 would have a deterministic seasonal component of 6 percent in the fourth quarter relative to the first. However, fluctuations in this seasonal difference would still exist due to random seasonal factors, and these would represent stochastic seasonality.

Deterministic seasonality can be handled by extracting seasonal means from the data, which is what seasonal dummies do in the regressions done here. Stochastic seasonality must be handled in other ways, such as through the fourth- and eighth-order autoregressive coefficients in the equations in the text.

Plosser (1975) provides a more complete discussion of these issues. Also, Sargent (1976) discusses how the use of seasonal filters to "pre-whiten" data can distort the results in Granger causality tests.

7. Also, the quarterly level observations used are **end-of-period** observations for the quarter rather than **quarterly averages.** Computing rates of change for averaged data can be shown to introduce spurious effects, and so this practice was avoided.

8. That is, the levels of the variables used here generally have increasing time trends, and so are very likely nonstationary. Therefore, percent changes were computed to attempt to induce stationarity. While inflation **rates** would also seem to have shown some trend over the last twenty years, these are, in any case, clearly more stationary than price **levels.** For the equations summarized in Table 1, the sum of the coefficients for the lagged dependent variable, while large, were uniformly below 1, in the .5–.7 range, suggesting that the implicit stationarity assumptions behind these equations hold at least approximately.

9. The St. Louis base is adjusted for shifts in deposits between large (high reserve requirement) banks and small (low reserve requirement) banks, as well as for shifts in general reserve requirements, in order to capture the "deposit-creating" power of a given stock of currency and reserves. For a detailed explanation of this series, see Anderson and Jordan (1968).

10. Using the variables in equation (1), if x were held at a stationary value x, y would approach the stationary value y, where

$$y = \alpha + \Sigma\beta_j y + \Sigma\gamma_j x, \text{ so that}$$

$$y = \alpha/(1 - \Sigma\beta_j) + [\Sigma\gamma_j/(1 - \Sigma\beta_j)]x.$$

Therefore, in the long-run, y responds to sustained changes in x by a factor of $\Sigma\gamma_j/(1 - \Sigma\beta_j)$, which is how the long-run effects in Table 1 are computed.

It is important to keep in mind that the significance of the F-statistic does not necessarily say anything about the significance of the long-run effects also shown in Table 1 (and in Table 2 below). This is because the F-statistic is for the hypothesis that the whole vector $(\gamma_1, \ldots, \gamma_8)$ in (1) (or $(\mu_1, \ldots, \mu_8)$ in (2)) is equal to a zero vector, while a test of the long-run effect would concern whether $\Sigma\gamma j$ in (1) (or $\Sigma \mu_j$ in (2) was equal to zero. Thus it could well be that the γ-vector differs significantly from zero, but that the individual coefficients vary in sign so that their sum is negligibly different from zero. Indeed, this is the case for the regressions of M-1- and M-2-growth rates on CPI inflation, as discussed in the text.

On the other hand, it should be clear that if the γ-vector (μ-vector) is not significantly different from zero, the sum of its coefficients cannot be significantly different from zero. Therefore, significance of the F-statistic is a necessary but not a sufficient condition for the significance of the long-run effect.

Tests of the significance of the long-run effect could be conducted by running another regression in which the long-run effect was constrained to zero, for (1) by imposing the linear constraint $\Sigma\gamma_j = 0$ on the data—just as the significance of the γ-vector was tested by running another regression with the 8 linear constraints $\gamma_j = 0$, $j = 1, \ldots, 8$ imposed on the equation, i.e. by dropping the x_{t-j} regressions from (1). These tests of the long-run effects were not conducted in order to economize on computer time, especially in view of the general lack of significant F-statistics for the accommodation equations initially.

11. This argument was attributed to Haberler by Milton Friedman.

12. Since the deficit and first difference in the money-supply series already have a decided trend, the seasonal means of these variables also have a trend over time, so that seasonal dummies would be expected to do a poor job of removing even deterministic seasonality from the data. Therefore, seasonally adjusted data were used for this test, further clouding the meaningfulness of its results.

13. The long-run effects can be easily computed from the estimated equations. However, computing the significance of differences in these long-run coefficients from zero or unity, involves estimating another equation (one in which the long-run effect is constrained to zero or one) and then comparing the two equations. Since a substantial number of equations had already been run in compiling Table 1, tests of the significance of the long-run effects were not generally conducted.

14. Gordon (1977) presents an interesting discussion of these and other effects, and the various theories citing them.

15. In considering these issues, Bazdarich (1978) found that money-supply growth was actually significantly lower in a number of Pacific Basin countries (including the U.S.) than would be expected given inflation and previous money growth. This also suggests a lack of accommodation in this period.

16. A similar calculation was performed by Friedman in an exchange between him and Modigliani (see Friedman and Modigliani (1977)), with much the same results.

In a subsequent part of that discussion, Modigliani claims that the Nixon Administration price controls "had no effect whatever on wages . . . (and) a small effect on prices, and that it washed out fairly quickly." Yet the simulations discussed in the text showed a run of positive simulation errors (over forecasts of inflation) during the controls period, and a run of negative errors immediately following the controls period. For example, the "bracketed sample" M-1 - CPI simulation from 1971.3–1972.4 showed six straight positive simulation errors generally larger than 2 percentage points on an annualized basis, and summing to 4 percent over "forecast" of the price level over the controls period. In 1973, when the controls were being phased out, two small overforecasts were followed by one small underforecast. Then, through 1974.4, five straight sizable under-forecasts were found, with a cumulative underforecast inflation in the post-controls period of 3.3%. This provides at least impressionistic evidence that the controls transferred price increases across periods.

Finally, even without any allowance for the possible delaying effect of controls on inflation, this simulation predicted a 9.2% CPI inflation rate in 1974—somewhat below the actual recorded rate of 12.2%, but nevertheless suggestive of a very inflationary monetary climate.

17. That is, inflation was forecasted for 1971.3 using previous money-supply growth, and this forecast amount was then used as the lagged dependent-variable value for 1971.3 in subsequent quarters, and so on. Thus, no actual 1971.3–1975.4 inflation information was used in generating these simulations, although actual money-supply growth was used.

18. Also, allowance was made for the effects of automatic transfers (ATS) on M-1. Due to the emergence of ATS, it's clear that M-1 demand would grow at a slower rate than previously, and therefore that a given rate of M-1 growth would be more inflationary immediately after the inception of ATS than before its inception. The Federal Reserve Board of Governors Staff estimates that ATS had about a 1.5% effect on M-1 growth in late 1978 and early 1979, by which time the effect was largely completed. Therefore, in these simulations, the actual levels of M-1 were increased by 0.75% in 1978.4, and by 1.5% in 1979.1 and 1979.2, so that M-1 growth rates in 1978.4 and 1979 were both increased by 0.75 percentage points. Other aggregates were not altered.

In order to continue the simulations through 1981.4, growth rates for the aggregates in the 1980.1–1981.4 period were assumed to be 5% for M-1, based on the current midpoint of the Federal Reserve's long-run target ranges.

19. That is, these simulations use actual money-supply growth through 1979.4. Since they are therefore conditioned on this information, they are not true forecasts.

20. The simulations or "conditional forecasts" shown in Table 4 represent the compounded sum of quarterly inflation forecasts for the year in question. Thus, they represent December/December or fourth-quarter/fourth-quarter measures of inflation. For this reason, lists of forecasts appearing in **Euromoney** (1978, 1979) and **Business Week** (1977, 1978) are not included in Table 4, since those forecasts were apparently on a year/year basis (using yearly average price levels). Still, this exclusion weakens the present paper's results, if anything, since the excluded forecasts are all much lower than the Table 4 results.

The forecasts shown in Table 4 were all computed on a fourth-quarter/fourth-quarter basis from published forecasts. In passing, it can be shown that year/year inflation figures inevitably involve heavy use of previously available figures, so that the ability to forecast December/December inflation rates is a better gauge of the predictive power of a given forecasting technique.

21. Actually, in view of the eight-to-ten quarter lag that occurs before money-supply expansion has had its full effect on inflation—implied by the equations estimated here and found in many other studies—the use of actual money-supply growth has little effect on predicted inflation rates in the first year of each simulation. The effect is probably less than half a percentage point, compared to simulations using, say, the midpoints of Federal Reserve target ranges or other forecasts of money-supply growth. Thus, the simulation predictions are in fact probably close to money-supply-based forecasts that might have been made at the dates shown.